Environmental Geology Lab 9 – Soil Resources

You have finally made it. You own a 4 km^2 plot ("ranch") in Jim Hogg County just south of Hebbronville. You want to manage this land properly. To do this you need to understand the behavioral characteristics of the soils present on your ranch. This lab will teach you some of the basics of soils.

Divide your plot into four 1 square kilometer blocks (see Figure 1). The number of pixels of each soil type is indicated below. Note that the color indicated in the Soil Type column indicates not the actual color of the soil but the color used on the map.

Table 1. Raw soil abundances per block.

SOIL TYPE	Northwest Block	Northeast Block	Southwest Block	Southeast Block
Yellow	396	347	373	425
Green	0	89	0	13
Purple	0	112	19	42
Lt Blue	54	33	46	63
Orange	92	3	123	28
Red	83	41	64	54
Total	625	625	625	625

Determine the percentage (roughly) of the soils present for the four blocks that make up your ranch.

Table 2. Calculated percent abundances of soil types per block.

SOIL TYPE	Northwest Block	Northeast Block	Southwest Block	Southeast Block
Yellow				
Green				
Purple				
Lt Blue				
Orange				
Red				

To understand soils one must know that the sedimentary particles that make up a soil is subdivided based on size.

Gravel	> 2 mm
Sand	1/16 to 2 mm
Silt	1/256 to 1/16 mm
Clay	< 1/256 mm

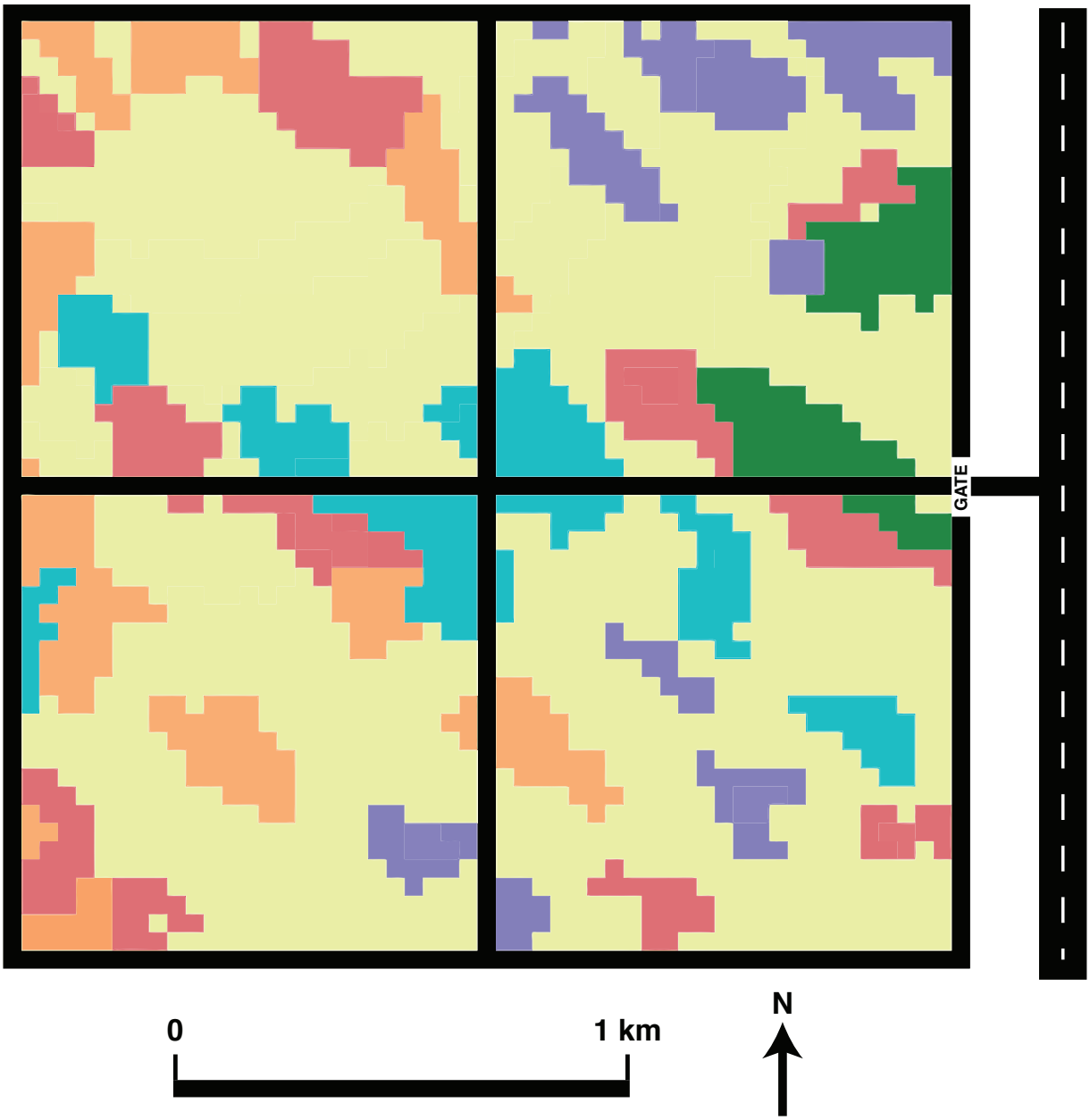

Figure 1. Soil types of Jim Hogg Ranch. Each block is 1 km X 1 km in dimensions.

One can analysis the grain-sizes of the top 1 meter of soil in a laboratory. The results are as follows:

Table 3. Sedimentary composition of soil types.

SOIL TYPE	% Clay	% Silt	% Sand	% Gravel	% Caliche
Yellow	12	13	55	18	2
Green	75	24	1	0	0
Purple	0	0	1	1	98
Lt Blue	0	1	98	1	0
Orange	1	50	49	0	0
Red	22	5	75	1	1

Note: the addition of caliche to Table 3. Your instructor will explain what caliche is!

QUESTIONS:

1. Verbally characterize, as if you were talking to a layperson, the six soil types that are present on your ranch. Is the soil mainly sand (call it sandy) or is it a mixture of sand and silt (call it mixed sand and silt).

Yellow _____

Green _____

Purple _____

Lt Blue _____

Orange _____

Red _____

2. An additional concept is sorting. Well-sorted sediment tends to consist of sediment that is close to the same size; whereas, poorly sorted sediment tends to have a wide range of particle sizes. Based on this information determine the relative sorting of your soil types (**except caliche**) Hint: If there is significant sediment (> 1 %) in three size classes the soil is likely poorly sorted.

Yellow _____

Green _____

Lt Blue _____

Orange _____

Red _____

The grain sizes of soil particles and its sorting profoundly influence the material properties of a soil. Properties such as the soil's permeability, the amount of water a soil can store (Available Water Capacity), and whether a soil has expansive capabilities (Shrink-swell potential). Soils that have high shrink-swell potentials expand when moisten and contract when dried and soils with this property tend to be rich in clay.

- Permeability is a measure of how fast water will drain through a soil. Typically measured in mm/hr.
- Available water capacity can be thought in % terms. In a volume of soil what is the maximum % of space that can be occupied by water. To convert available water capacity numbers in mm into a % divide by 10 .

Listed on the top of the next page is a table that states these characteristics for each of the six soil types present on your ranch. Values are valid for the uppermost 1 meter of your soil.

Table 4. Material properties of soils.

SOIL TYPE	Permeability (mm/hr)	Shrink-swell potential	Available Water Capacity (mm) or % Water
Yellow	30	Low	120 mm or 12%
Green	1	High	50 mm or 5%
Purple	0	None	0 mm or 0%
Lt Blue	330	None	50 mm or 5%
Orange	30	Low	130 mm or 13%
Red	10	Moderate	80 mm or 8%

QUESTIONS:

3. Determine the approximate average grain-size of your soil types (**except caliche**). Hint: Select the sediment size type that defines the mid-point in size with half the sediment size smaller and the other half bigger that the mid-point sediment size.

Yellow _____

Green _____

Lt Blue _____

Orange _____

Red _____

4. Soils yellow and light blue have approximately the same average grain size (0.5 mm). However the permeability of these soils differs radically (see Table 4). Why? Hint: think about the sorting of these soils and how sorting can influence the movement of water through these soils. Refer to lab #4 (pg. 1)

5. Based on the above information, which of the two soil types yellow or light blue discussed in question #4 will have the greatest likelihood of experiencing flooding during intense rain storms in low laying areas because of its lower permeability? Circle one of the above soils.

6. Let's assume that you like to fish. On what type of soil would you be most likely to dig out a stock pond on your ranch? Justify your answer! Considerations: ease of excavation (try digging up caliche - do not) and likelihood of water infiltration from your pond once it is filled with water (i.e soil must have a very low permeability). In other words you need a soil type without caliche and a very low permeability.

Soil _____

7. Would it be a good idea to build a road around your new stock pond? Additionally, would it be a good idea to build your new house on the same soil type that you excavate for your stock pond? Explain! Hint: look closely at the type of sediment and its material properties such as shrink-swell potential making up the soil.

8. Living outside of the city limits requires you to install a septic system for the new house you would like to build on your ranch. For a septic system to be effective water must be able to infiltrate into the ground at a moderate rate (10 to 100 mm/hr) and ideally the soil surrounding the septic system will have some clay (>10%), which acts as an effective filter absorbing harmful bacteria. Based on this information which two soil types would be most suitable for the installation of a septic system?

Soils _____ _____

9. **Of the soil types selected in question 8**, which one has the maximum permeability? This is the soil on which you will build your home.

Soil _____

10. You would like to have your stock pond within 100 m of your new house. Where on your ranch can you site your house given this constraint? Additionally, note that the assess road to your property enters from the east near the junction of the northeastern and southeastern blocks and your home needs to be within 200 m of this point. Based on this information locate your home on the map. Draw dots on Figure 1 and label 'home" and "stock pond". Remember each block is 1 km wide and 1 km = 1000 m. The procedure is as follows:
    (1) Use a compass and draw a circle centered on the junction that is 200 m in radius.
    (2) Draw dot (labeled house) within this circle on the soil type selected in question #9. Then erase the circle.
    (3) Using a ruler draw a second dot (labeled stock pond) within the soil in selected in question #6. Make sure that the stock pond is within 100 m of your house. You may have to slightly move your house location to make this so. If you move your house do not move further than 200 m from the road junction.

11. You would like to make some money from your ranch. Resources like sand, gravel, and caliche can be economically extracted and sold if no processing is required to extract these materials (i.e. these materials are essentially pure consisting of >95% the same material). Based on this information what two geologic resources are present on your ranch?

Resources _____ _____

12. Additionally, a significant cost is the building of a heavy-duty road to remove these resources and you like to have this road extend a relatively short distance away from your house (< 0.5 km) to keep the extraction process economic. Based on this information identify specific areas where you can economically extract these resources! The procedure is as follows:
    (1) Use a compass and draw a circle that extends 500 m from your house.
    (2) Draw roads on the map from your house to the areas you identified as having resources. **Make sure your roads avoid area.with excessive shrink-swell potential -** the soil type that you build your stock pond on in question #6. When you have finished erase your circle.

Draw your roads with care. It cost money to build them positioning them in the correct place could be the difference in whether your ranch is profitable.

Another economic activity of your ranch is cattle ranching. As a result you are interested in whether there is soil water available to support your ranching activities. On September 15th the Center for Earth and Environmental Studies radar recorded the rainfall over a one hour period during the early evening over the 4 km^2 of your ranch. The next rainfall event is in October.

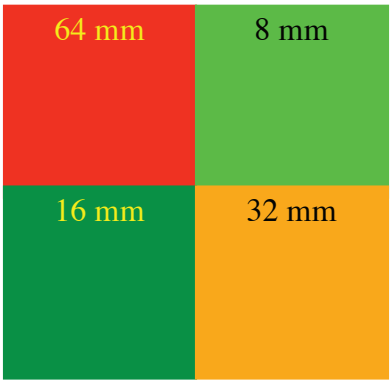

Figure 2. RADAR PRECIPITATION FOR YOUR RANCH

Remember the hydrologic equation from the hydrologic cycle lab (Lab 1):

(1) $P = ET + Q + I$

Where P = precipitation (rain), ET = evapotranspiration, Q = discharge, and I = infiltration. The focus of our ranching activities will be in the southeastern square kilometer of your ranch.

If there is more rainfall then can be absorbed by the ground:

(2) If $P >$ Permeability then $I =$ Permeability

If all of the rain can be absorbed by the ground then:

(3) If $P \leq$ Permeability then $I = P$ (or rain)

Using the permeability information in Table 4 and equations 2 and 3 determine the amount of water that infiltrated into each of the soil types in the southeastern block during the storm on September 15th, which recorded 32 mm.

Table 5. Water infiltration into soils from the southeastern block

SOIL TYPE	Water Infiltration (I, mm)
Yellow	
Green	
Purple	
Lt Blue	
Orange	
Red	

Assume that before September 15th the soils had zero Available Water Capacity, a common condition in this region. So the only water in the soil was added during the storm of September 15th.

On a daily basis:

(5) Soil Water for Current Day = (Soil Water for Previous Day) - (ET_{day})

Next, determine how long this water will last at an evaporation rate of 5 mm/day (ET_{day}) from September 16 to 21.

Table 6. Water loss due to evapotranspiration from soils in the southeastern block

SOIL TYPE	Initial Soil Water I (mm)	Soil Water 9/16/2002 eve.	Soil Water 9/17/2002 eve.	Soil Water 9/18/2002 eve.	Soil Water 9/19/2002 eve.	Soil Water 9/20/2002 eve.	Soil Water 9/21/2002 eve.
Yellow							
Green							
Purple							
Lt Blue							
Orange							
Red							

QUESTIONS:

13. How long can you sustain grazing activities on your ranch without having to resort to feeding your cattle with hay? Note that native ranchland vegetation tends to die when **Soil Moisture = 0** for an extended period of time.

14. Which soil types are best suited for cattle grazing (i.e. which soils have the highest available water capacity)? Which which two soils are most and least suited for cattle grazing? Explain!

Most Suited _____ _____

Least Suited _____ _____

15. Assuming road access was not a problem do you think you can conduct grazing activities within all four of the square kilometer blocks that defines your ranch? Are the two soil types that are best suited for cattle grazing present in all four blocks that define the ranch. Elaborate.

16. If you had access to good quality groundwater irrigated agricultural is in theory possible. Given the intense evaporation endemic to this region you want to select a soil that has the has a high available water capacity (> 100 mm). Also, you want to avoid soils that have excessive gravel or caliche; these materials are not kind to plows. Based on this information what soil type will be the best choice for this purpose? Explain!

Soil _____

17. Extend your road network to the nearest area soil area from your house that can support irrigated agricultural activity.

18. In the yellow soils away from your house there is a significant vegetation cover of mesquite and grasses. Discuss the pros and cons associated with clearing this brush. Your answer should address how brush clearing can impact both water conservation and soil erosion on your ranch.